# IDAMEAN (LATE CAMBRIAN) TRILOBITES FROM THE DENISON RANGE, SOUTH-WEST TASMANIA

*by* J. B. JAGO

ABSTRACT. Fourteen species of trilobites are described and figured from three faunas within the clastic submarine fan sequence of the Singing Creek Formation, Denison Range, south-west Tasmania. It is suggested that all faunas fall within the top three Idamean (early Late Cambrian) zones of *Proceratopyge cryptica*, *Erixanium sentum*, and *Stigmatoa diloma*. The genus *Denagnostus* gen. nov., its type species *D. corbetti* sp. nov., and *Pseudagnostus idalis denisonensis* subsp. nov. are erected. *Proceratopyge* is reviewed and its constituent species split into two broad groups based on cranidial characteristics. *Proceratopyge gordonensis* sp. nov., *Aphelaspis cantori* sp. nov., and *Pseudoyuepingia vanensis* sp. nov. are erected.

THE Upper Cambrian trilobites from the Singing Creek Formation of the Denison Range, south-west Tasmania, are the first Cambrian fossils to be described from the Adamsfield Trough. The Middle Cambrian to Lower Ordovician stratigraphy of the Denison Range area (Corbett 1975) may be summarized as follows:

| | | |
|---|---|---|
| Denison Supergroup | Squirrel Creek Formation | 600 m |
| | Reeds Conglomerate | 1,560 m |
| | Great Dome Sandstone | 510 m |
| | Singing Creek Formation | 720 m |
| | angular unconformity | |
| | Trial Ridge Beds | 500 m |

The upper part of the Trial Ridge Beds contains late Middle Cambrian (*Lejopyge laevigata* Zone) fossils, including the agnostoid trilobites *Tasagnostus*, *Hypagnostus*, *Clavagnostus*, and *Ptychagnostus* (Jago 1979). The Great Dome Sandstone is a shallow marine-deltaic-fluvial sequence which contains abundant trace fossils, rare inarticulate brachiopods, and a gastropod similar to *Kobayashiella* (Corbett 1975).

The Singing Creek Formation comprises 720 m of quartz wacke turbidites interbedded with fossiliferous siltstone, siliceous conglomerate, and slump sheets deposited as a submarine fan complex in a fault controlled basin (Corbett 1972, 1973, 1975). In the Denison Range, fossils are found over three stratigraphic intervals (text-fig. 1); the trilobites are described herein. Fossils from stratigraphic equivalents of the Singing Creek Formation found elsewhere in the Adamsfield Trough will be described in later papers.

The specimens from each fossiliferous interval were collected in 1967 and 1968 by K. D. Corbett as bulk samples, rather than bed by bed, because of the nature of the outcrop and the difficulties of collection in this rather inaccessible area. However, with the exception of the trilobites described below as Leiostegiacea gen. et sp. indet., all of the relatively common species from each fossiliferous interval occur throughout the range of available lithologies. Leiostegiacea gen. et sp. indet. is restricted to a slightly coarser siltstone than the other fossils.

The 'bottom fauna' (*c*. 185–240 m above the base of the Singing Creek Formation) contains trilobites (*Micragnostus* sp. 2, *Pseudagnostus idalis denisonensis* sp. nov., *Denagnostus corbetti* gen. et sp. nov., Agnostoid gen. et sp. indet., *Eugonocare* sp., Dokimocephalidae gen. et sp. indet., and *Proceratopyge* sp.) and brachiopods (*Lingulella*(?) sp., an acrotretid, and *Billingsella* sp.); only *Pseudagnostus idalis denisonensis* and *Billingsella* sp. are reasonably abundant.

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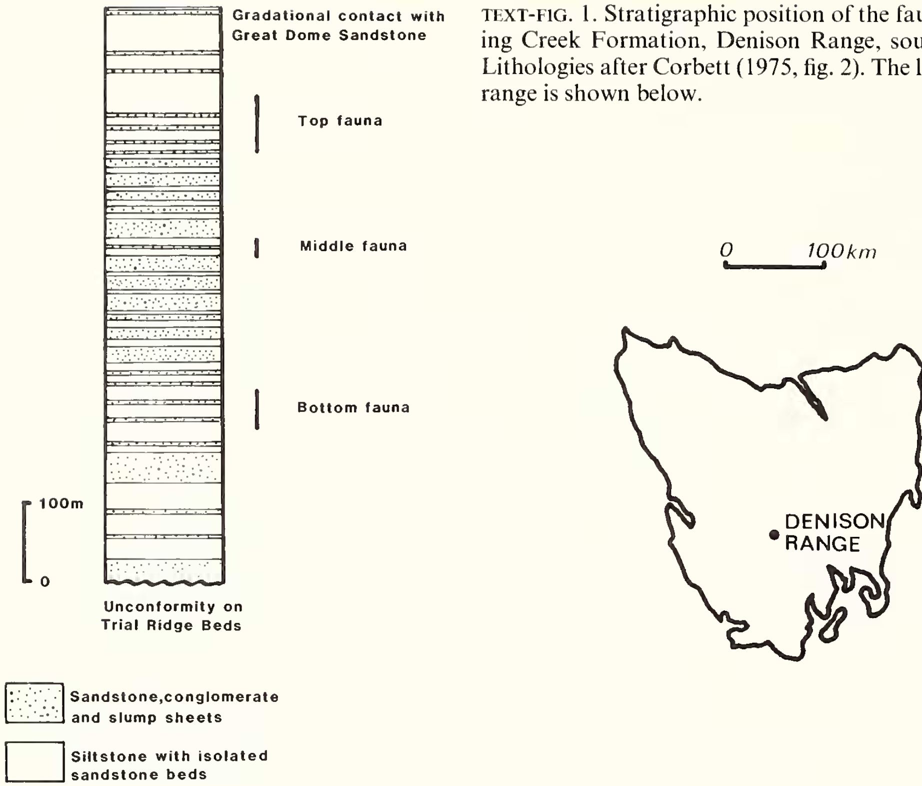


TEXT-FIG. 1. Stratigraphic position of the faunas from the Singing Creek Formation, Denison Range, south-west Tasmania. Lithologies after Corbett (1975, fig. 2). The location of Denison range is shown below.

The 'middle fauna' (*c.* 410–430 m above the base of the Singing Creek Formation) contains trilobites (*Denagnostus corbetti* gen. et sp. nov., *Aphelaspis cantori* sp. nov., *Proceratopyge gordonensis* sp. nov., *P.* sp., *Pseudoyuepingia vanensis* sp. nov.), trilobite tracks, hyolithids (gen. et sp. indet.), and brachiopods (*Lingulella*(?) sp. and *Obolus*(?) sp.); *Proceratopyge gordonensis*, *P.* sp., and *Pseudoyuepingia vanensis* are common.

The 'top fauna' (*c.* 540–610 m above the base of the Singing Creek Formation) is by far the richest and contains trilobites (*Micragnostus* sp. 1, *Pseudagnostus idalis denisonensis* subsp. nov., *P.* cf. *i. sagittus*, *P.* sp., *D. corbetti* gen. et sp. nov., *A. cantori* sp. nov., Leiostegiacea gen. et sp. indet., *Proceratopyge gordonensis* sp. nov., *P.* sp., and a cranidium gen. et sp. indet.), trilobite tracks, hyolithids (gen. et sp. indet.), and brachiopods (*Obolus*(?) sp., two other species of unassigned Obolidae, a different species of acrotretid to that found in the bottom fauna, and *Billingsella* sp.).

### *Correlation*

None of the species found in the Denison Range faunas has been recorded elsewhere, so an exact zonal age cannot be determined. However, the presence of *Eugonocare* sp. in the 'bottom fauna' and that of a new subspecies of *Pseudagnostus idalis* in both the 'bottom fauna' and 'top fauna' suggest, by comparison with the range charts given by Henderson (1976) and Shergold (1982), that all faunas are of Idamean age. This is supported by the presence of *Proceratopyge gordonensis* sp. nov. and *P.* sp., both of which (particularly *P.* sp.) are similar to the Idamean species *P. lata*.

In Queensland, neither *Pseudagnostus idalis* nor any of its subspecies range up into the *Irvingella tropica* Zone, the lowest zone of the post-Idamean. Although an exact correlation is not possible, this suggests that the fossils described herein fall within the top three Idamean zones, i.e. the *Proceratopyge cryptica*, *Erixanium sentum*, and *Stigmatoa diloma* zones.

Probably the main reason that there are no species in common between Queensland and Tasmania is that the faunas from the two areas occur in sediments of contrasting depositional environments. The Queensland faunas are found in shallow water carbonate sequences while those of Tasmania are found in a more offshore, clastic submarine fan sequence.

### *Faunal affinities*

The faunas described herein show affinities with other Late Cambrian faunas of Australia, northern Victoria Land (Antarctica), China, Korea, Kazakhstan, Alaska, and the Siberian Platform.

*Pseudoyuepingia* Chien is here described from Australia for the first time, although previously reported from China (Chien 1961; Lu and Lin 1980) and, as *Iwayaspis*, from Korea (Kobayashi 1962) and Alaska (Palmer 1968). The closely related genus *Yuepingia* is known from China (Lu 1956*b*; Lu and Lin 1980), Alaska (Palmer 1968), and Queensland (Henderson 1976).

*Aphelaspis cantori* sp. nov. is most closely related to *A. australis* from Queensland (Henderson 1976) and ?*A.* sp. aff. *A. australis* from western New South Wales (Jell *in* Powell *et al.* 1982). *Kobayashiella problematica* of Ivshin (1962) from Kazakhstan is closely related to *A. cantori*.

*Proceratopyge* is a widespread Late Cambrian genus. *P. gordonensis* sp. nov. and *P.* sp. are best compared with the species of *Proceratopyge* from western Queensland described by Whitehouse (1939), Öpik (1963), Henderson (1976), and Shergold (1982), and with *P.* cf. *P. lata* of Shergold *et al.* (1976) from northern Victoria Land, Antarctica. Among other species of *Proceratopyge*, the Chinese form *P. fenghwangensis* Hsiang appears to be closest to the Tasmanian species.

As noted by Shergold (1982, p. 38) *Eugonocare* is known from Queensland, Victoria, China, and the Siberian Platform. *Pseudagnostus idalis denisonensis* sub sp. nov. is a subspecies of *P. idalis* from Queensland (Öpik 1967; Shergold 1982).

### *Material and methods*

All Tasmanian Cambrian fossils have undergone tectonic distortion to some extent. The terminology used herein with respect to distortion is the same as that used by Jago (1976), and is based on Henningsmoen (1960). The trilobites from the Denison Range area, however, are among the least distorted of Tasmanian Cambrian faunas. All trilobites from these localities are preserved as internal and external moulds in weathered siltstone or very fine sandstone. For description, silicone rubber casts of the external moulds were prepared and then photographed after whitening with magnesium oxide. The terminology used for agnostoid trilobites is essentially that of Robison (1982); that used for polymeroid trilobites is after Harrington *et al.* (1959). All specimens are housed in the collection of the Geology Department, University of Tasmania (UT).

## SYSTEMATIC PALAEONTOLOGY

Order MIOMERA Jaekel, 1909
Superfamily AGNOSTACEA M'Coy, 1849
Family AGNOSTIDAE M'Coy, 1849
Subfamily AGNOSTINAE M'Coy, 1849
Genus MICRAGNOSTUS Howell, 1935

*Type species*. *Agnostus calvus* Lake, 1906, p. 23, pl. 2, fig. 18.

*Micragnostus* sp. 1

Plate 24, fig. 1

*Material*. A moderately well-preserved internal mould of a cephalon (UT 88515) and an associated partial pygidium comprising only the posterior border area.

*Description*. Cephalon slightly longer than wide. Very wide border furrow; narrow border. At anterior, width of border almost 0·2 that of cephalon. Unconstricted acrolobe tapers markedly to anterior. Preglabellar median furrow absent; genae smooth. Well-developed axial furrows. Glabellar length *c.* 0·6 that of cephalon; glabella tapers markedly to broadly rounded anterior. Well-developed transverse glabellar furrow curves gently rearwards. Details of posteroglabella poorly preserved.

All that can be seen of the associated pygidium is that the posterior border is very wide.

*Discussion*. Fortey (1980) and Shergold and Sdzuy (1984) discussed *Micragnostus*, *Geragnostus*, and related genera.

*Micragnostus* sp. 2

Plate 24, figs. 2, 3

*Material*. Two poorly preserved cephala (UT 89510) and a poorly preserved pygidium (UT 89516) are included together in a species referred to herein as *Micragnostus* sp. 2. The preservation is such that no formal description or discussion is warranted.

Family DIPLAGNOSTIDAE Whitehouse, 1936
Subfamily PSEUDAGNOSTINAE Whitehouse, 1936
Genus PSEUDAGNOSTUS Jaekel, 1909
Subgenus PSEUDAGNOSTUS Jaekel, 1909

*Synonymy*. See Shergold (1977, pp. 98–100).

*Type species*. *Agnostus cyclopyge* Tullberg, 1880, p. 26, pl. 2, fig. 15*a*, *c*.

*Diagnosis*. See Shergold (1977, p. 92).

*Pseudagnostus* (*Pseudagnostus*) *idalis* Öpik, 1967
*Pseudagnostus* (*Pseudagnostus*) *idalis denisonensis* subsp. nov.

Plate 24, figs. 4–12

*Diagnosis*. A subspecies of *P*. (*P*. ) *idalis* with a centroposteriorly placed glabellar node and a very wide cephalic border.

*Holotype*. The cephalon, UT 88519 (Pl. 24, fig. 6) is designated as holotype.

*Material*. Over twenty cephala and pygidia are available (including UT 88353, 88366, 88371, 88376, 88381, 88382, 88494, 88499, 88519).

*Description*. Gently convex cephalon slightly wider than long. Border widens markedly to anterior. Border furrow very wide and moderately deep. Unconstricted acrolobe length *c.* 0·85–0·90 that of cephalon. Well-defined preglabellar median furrow shallows anteriorly. Genae smooth. Glabella has elongated oval shape; length 0·65–0·70 that of cephalon; at transverse glabellar furrow, glabella width *c.* 0·30 that of cephalon.

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EXPLANATION OF PLATE 24

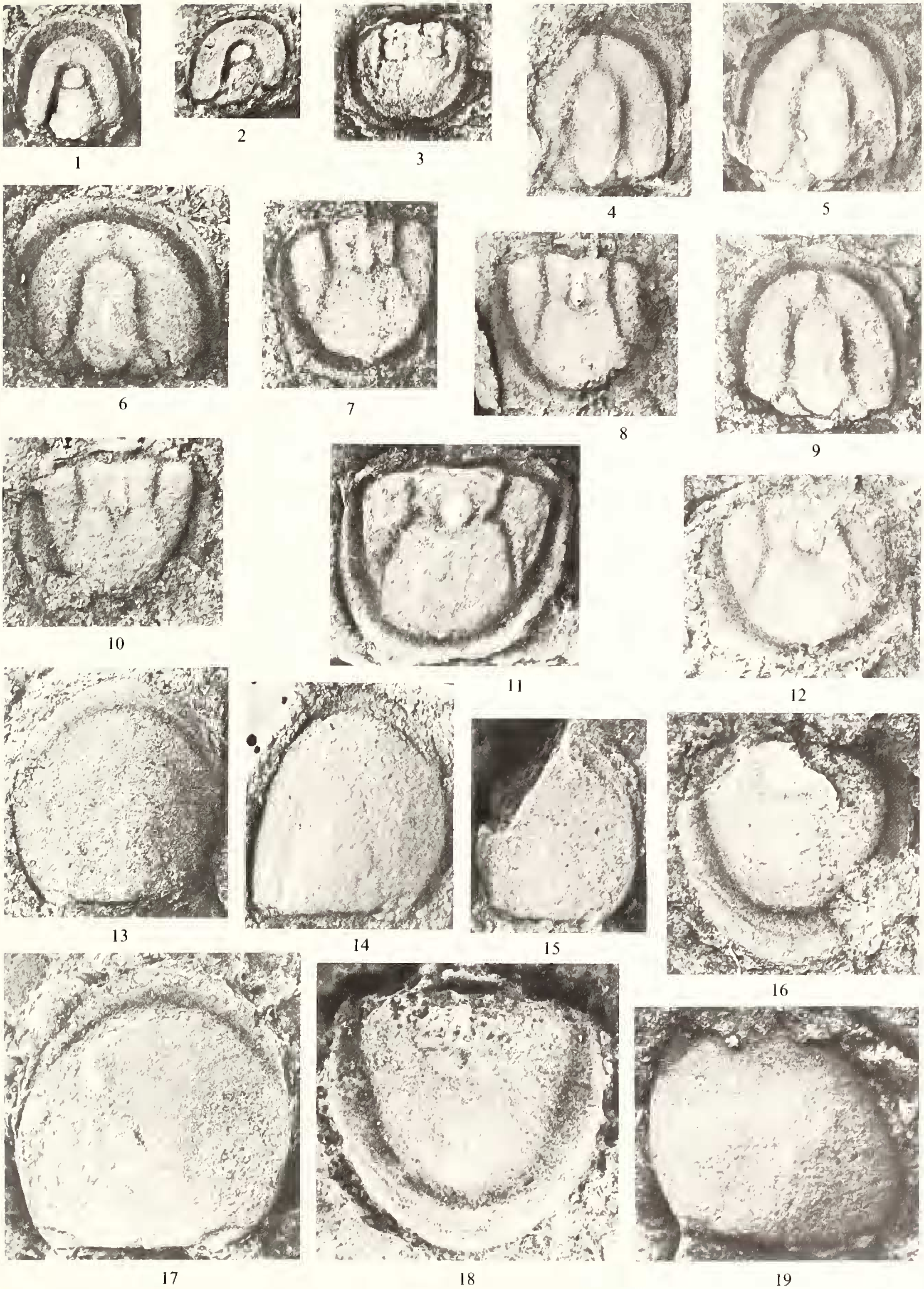
Fig. 1. *Micragnostus* sp. 1, UT 88515, cephalon, internal mould, × 7·5.

Figs. 2 and 3. *M*. sp. 2, from 'bottom fauna'. 2, UT 89510, cephalon, internal mould (intermediate distortion), × 9. 3, UT 89516, pygidium, external mould, × 9.

Figs. 4–12. *Pseudagnostus idalis denisonensis* subsp. nov. 4, UT 88376, cephalon, external mould, × 10. 5, UT 88381, cephalon, internal mould, × 10. 6, UT 88519, holotype cephalon, external mould, W form, × 10. 7, UT 88353, cephalon, external mould, L form, × 10. 8, UT 88366, pygidium, external mould, L form, × 10. 9, UT 88499, cephalon, internal mould, × 10. 10, UT 88382, pygidium, external mould, × 10. 11, UT 88371, pygidium, internal mould, W form, × 10. 12, UT 88494, pygidium, external mould, W form, × 10.

Figs. 13–19. *Denagnostus corbetti* gen. et sp. nov. 13, UT 88463, holotype cephalon, external mould, × 9. 14, UT 88394, cephalon, external mould, × 9. 15, UT 88389a, cephalon, external mould, × 9. 16, UT 88513, pygidium, external mould, × 9. 17, UT 89424, from 'middle fauna', cephalon, internal mould, × 9. 18, UT 89443, from 'bottom fauna', pygidium, internal mould, W form, × 9. 19, UT 88495, cephalon, internal mould, × 9.

All specimens from 'top fauna' (see text-fig. 1) unless otherwise stated.




JAGO, *Micragnostus*, *Pseudagnostus*, *Denagnostus*

Glabella bounded by wide, shallow axial furrows which shallow slightly to anterior. Small, simple basal lobes linked by narrow connective band. Faintly outlined, V-shaped, transverse glabellar furrow. Pair of faintly developed lateral glabellar furrows just anterior of midpoint of glabella. Elongated node on centroposterior part of glabella.

Gently convex pygidium slightly wider than long.

Wide, elevated border widens posteriorly; wide, shallow border furrow. Narrow, elevated, strongly geniculate shoulders. Wide, shallow, articulating furrow arched posteriorly; short (sag.), elevated, articulating half-ring. Unconstricted or very slightly constricted acrolobe.

Anteroaxis outlined by shallow axial furrows which converge gently to the $F_2$ furrow. $M_2$ about twice as long (sag.) and slightly narrower than $M_1$. Prominent elongated node on $M_2$ extends across $F_2$ and just on to posteroaxis. $F_1$ furrow almost obsolete; $F_2$ furrow shallow and directed inwards and slightly to posterior from either end.

Accessory furrows fade posteriorly; if continued across border, they would strike pygidial margin a little behind posterolateral spines. Short posterolateral spines lie just forward of line drawn across rear of deuterolobe. Small terminal axial node visible on some specimens. Narrow, smooth pleural areas.

*Discussion.* The specimens clearly fall within the *P. idalis* species complex as described and discussed in some detail by Shergold (1982); he noted that this complex should be investigated at the subspecific level. *P. i. denisonensis* subsp. nov. is close to *P. i. idalis* Öpik, 1967, as discussed by Shergold (1982). The cephalon of *P. i. denisonensis* differs from that of *P. i. idalis* and that of *P. i. sagittus* in that the glabellar node of *denisonensis* is placed further to the posterior than that of the other two subspecies. The cephalic border of *P. i. denisonensis* is wider than that of either *P. i. idalis* or *P. i. sagittus*. The pygidia of *P. i. idalis* and *P. i. denisonensis* appear to be identical, but the pygidial spines of *P.i. sagittus* are placed further to the posterior than those of *P. i. denisonensis.* The slightly different appearance of the pygidium figured in Plate 24, fig. 11 is thought to be due to the fact that it is preserved in shale, whereas all other figured specimens are preserved in siltstone.

### *Pseudagnostus* (*Pseudagnostus*) cf. *idalis sagittus* Shergold, 1982

Plate 25, fig. 3

*Material.* One pygidium (UT 88478) associated with *P.* (*P.*) *idalis denisonensis* sp. nov.

*Description.* Length (including axial half-ring), 3·6 mm; width, 3·7 mm. The pygidium has similar axial features to *P. i. idalis*, *P. i. sagittus*, and *P. i. denisonensis.* However, its pygidial margins are markedly tapered, and the border spines are set closer together than those of the other three subspecies. The spines are placed level with the end of the deuterolobe, rather like those of *P. i. sagittus.*

*Discussion.* The similarity of axial characteristics and the fact that there is only one known specimen of this type raises the possibility that it is an aberrant pygidium of *P. i. denisonensis.* However, due to the retral position of the spines, it is referred to *P.* (*P.*) cf. *i. sagittus* Shergold.

### *Pseudagnostus* sp.

Plate 25, fig. 5

*Material.* An internal mould of a cephalon (UT 88517).

*Description*: Gently convex cephalon, 4 mm in length, about as wide as long. Narrow border; wide, shallow border furrow. Unconstricted acrolobe; smooth genae. Well-defined preglabellar median furrow. Markedly tapering glabella has length about two-thirds that of cephalon. Shallow axial furrows. Very shallow, almost straight transverse glabellar furrow. Pair of faintly developed lateral glabellar furrows at midpoint of glabella. Small circular node placed between lateral glabellar furrows. Small, simple basal lodes.

*Discussion.* The combination of a markedly tapering glabella and a wide border distinguish this cephalon from most species of *Pseudagnostus.* It may belong in an undescribed species of *Pseudagnostus*, but without an associated pygidium a new species cannot be erected. Other species of *Pseudagnostus* which show this combination include the cephalon illustrated by Bell and Ellinwood (1962, pl. 36, fig. 11) as *P. communis*, although Palmer (1968, p. 30) considered this specimen not to belong in *communis*. *P. chinensis* (Dames) shows a similar combination of markedly tapering glabella and a wide border, as illustrated by Schrank (1974, pl. 1, figs. 1–7), although its glabella is shorter and its genae are faintly scrobiculate, a feature which is not apparent in the Tasmanian specimen.

### Genus DENAGNOSTUS gen. nov.

*Type species*. *Denagnostus corbetti* sp. nov.

*Diagnosis*. Almost effaced, gently convex cephalon with subovoid outline and straight posterior margin. Unconstricted acrolobe. Faintly outlined glabella; rounded glabellar rear; very faintly outlined V-shaped transverse glabellar furrow; spectaculate; small centrally placed glabellar node. Pair of large anterolateral lobes immediately anterior of node. Wide anterior border narrows posteriorly and disappears about halfway to posterior margin. Pygidium slightly more convex than cephalon; pygidial acrolobe slightly constricted. Wide border with very small posterolateral spines placed well forward of acrolobe posterior. Faint ridge around centre of posterior border, indicating that pygidium is slightly zonate. Faintly outlined axis has two small anterior segments and long slightly expanded posteroaxis which reaches acrolobe posterior; small terminal axial node. Low elevated node on second axial segment.

*Discussion*. The effaced nature of *Denagnostus* hinders its classification, but it appears to be most closely related to *Rhaptagnostus* Whitehouse, a member of the Pseudagnostinae. Similarities between the two genera include the shape and essentially effaced nature of the cephala and pygidia, the slightly constricted pygidial acrolobes, and the presence of very small pygidial posterolateral spines placed well forward of the acrolobe posterior. In addition, the transverse glabellar furrow of *Denagnostus* is V-shaped like that of *Rhaptagnostus*. *Denagnostus* shows no clearly defined deuterolobe, but neither do many of the species of *Rhaptagnostus* illustrated by Shergold (1975, 1977, 1980).

*Denagnostus* differs from *Rhaptagnostus* in that it is spectaculate rather than papilionate, i.e. the axial glabellar node of *Denagnostus* lies to the rear of the anterolateral glabellar lobes rather than between them (see Shergold 1975, 1977). It could be argued that *Denagnostus* is simply a spectaculate species of *Rhaptagnostus* and that the diagnosis of *Rhaptagnostus* given by Shergold should be expanded to allow for this. However, as discussed by Shergold (1977), the position of the axial glabellar node is important, from the viewpoint of both anatomy and classification; hence *Denagnostus* should not be included in *Rhaptagnostus*.

The slightly zonate nature of the pygidial border separates *Denagnostus* from all other known members of the Pseudagnostinae which have simplimarginate borders. *Denagnostus* differs from all previously described agnostoid genera in the way in which the very wide anterior cephalic border narrows markedly to the posterior and disappears about half-way around the cephalon.

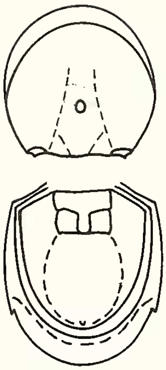
Apart from the features noted above, *Denagnostus* differs from *Neoagnostus*, which has a spectaculate glabella, in the shape of the shields: those of *Neoagnostus* are generally subquadrate whereas those of *Denagnostus* are subovoid. The pygidial border spines of *D. corbetti* are placed much further forward than those of any species of *Neoagnostus*. The anterior part of the pygidial axis of many species of *Neoagnostus* show three segments in that part of the axis outlined by axial furrows (Shergold 1977), whereas in *D. corbetti* only two such segments are outlined. *Denagnostus* differs from many species of *Pseudagnostus* in that it shows no clearly defined deuterolobe. *D. corbetti* has a faint V-shaped transverse glabellar furrow, whereas those in *Pseudagnostus* are either straight or gently curved to the posterior.

### *Denagnostus corbetti* sp. nov.

Plate 24, figs. 13–19; Plate 25, figs. 1 and 2; text-fig. 2

*Diagnosis*. See generic diagnosis.

*Holotype*. UT 88463 (Pl. 24, fig. 13) is selected because it is the best preserved cephalon.



TEXT-FIG. 2. Reconstruction of *Denagnostus corbetti* gen. et sp. nov. Cephalon based on UT 88463 (Pl. 24, fig. 13); pygidium based on counterparts UT 88511 and UT 88495 (Pl. 25, figs. 1 and 2), ×5.

*Material*. One reasonably well-preserved cephalon (UT 88463), two partially preserved pygidia as external moulds (UT 88511, 88513), and several reasonably preserved internal moulds of both cephala and pygidia (including UT 88495, 89424, 89443).

*Description*. Gently convex subovoid cephalon, about as wide as long, with almost straight posterior margin. Margins of cephalon diverge anteriorly up to a point just under half-way to anterior of cephalon; from this point, margins converge to give anterior margin a subelliptical outline.

Border absent in posterior half of cephalon, except for very short posterolateral spines which are separated from acrolobe by narrow, shallow posterior border furrows. Almost flat border appears about half-way along cephalic margins and widens markedly to anterior of cephalon, where it is quite wide. Narrow, shallow border furrow. (The apparent very narrow border, placed posterolaterally on right side of UT 89424 (Pl. 24, fig. 17) is an artefact of preparation.)

Glabella only faintly outlined at posterior; is markedly convergent to anterior and fades out in that direction; length about two-thirds that of cephalon. The basal lobes are of moderate size (Pl. 24, fig. 13); rear of glabella rounded. To anterior of basal lobes, glabella tapers to broadly rounded front, only seen faintly in some specimens (Pl. 24, fig. 14) and not at all in others. Very faintly outlined V-shaped transverse glabellar furrow. Small node at about centre of glabella. Spectaculate. Pair of large anterolateral lobes immediately anterior of node.

Pygidium a little longer than wide, and slightly more convex than cephalon. Acrolobe slightly constricted in some specimens (best seen on Pl. 24, fig. 18).

Wide, shallow border furrow; border wide and almost flat at posterior, becoming narrow and more elevated anteriorly. Very small posterolateral spines placed well forward of acrolobe posterior. Around centre of posterior border, paralleling acrolobe margin, is a low ridge which meets margin a little anterior of border

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EXPLANATION OF PLATE 25

Figs. 1 and 2. *Denagnostus corbetti* gen. et sp. nov. 1, UT 88511, pygidium, external mould, L form, ×9. 2, UT 88495, pygidium, internal mould, L form (counterpart of UT 88511), ×9.

Fig. 3. *Pseudagnostus* (*Pseudagnostus*) cf. *idalis sagittus* Shergold, 1982, UT 88478, pygidium, external mould, ×9.

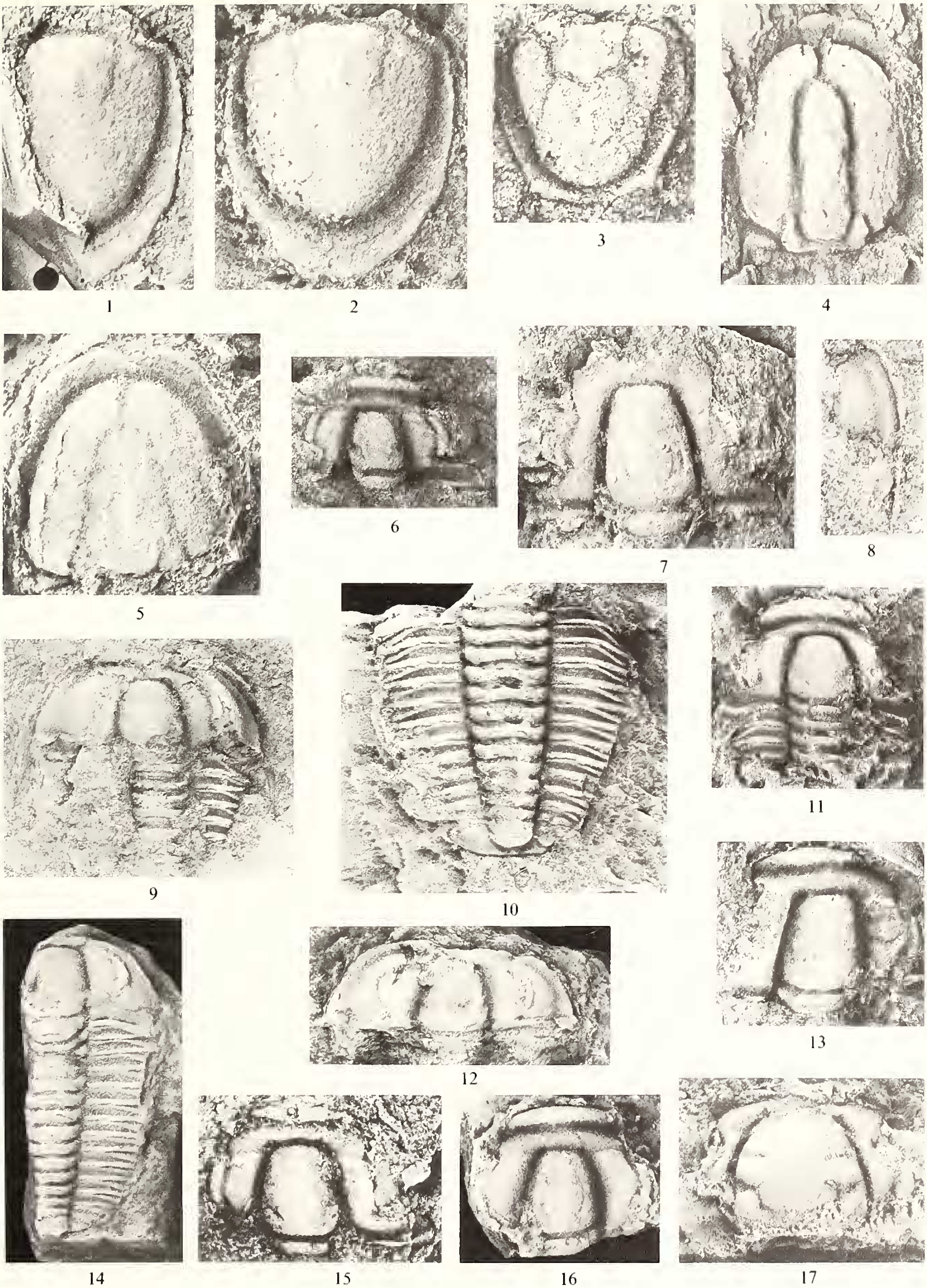
Fig. 4. Agnostoid gen. et sp. indet., UT 89438b, from 'bottom fauna', cephalon, external mould, L form, ×10.

Fig. 5. *P.* sp., UT 88517, cephalon, internal mould, ×9.

Figs. 6–16. *Aphelaspis cantori* sp. nov. 6, UT 88521, holotype cranidium, external mould, W form, ×4. 7, UT 89406, from 'middle fauna', cranidium, external mould, L form, ×4. 8, UT 88520a, librigena, internal mould, ×4. 9, UT 88520b, cephalon and part of thorax, external mould, ×3. 10, UT 88393, pygidium and most of thorax, internal mould, ×4. 11, UT 88532, cranidium and anterior part of thorax, internal mould, W form, ×3. 12, UT 88533, almost complete cephalon, internal mould, W form, ×4. 13, UT 88393a, cranidium, internal mould, L form, ×4. 14, UT 88538, specimen showing most of cranidium, part of a librigena, and most of thorax and pygidium, internal mould, ×3. 15, UT 88522, cranidium, external mould, W form, ×4. 16, UT 89424, from 'middle fauna', cranidium, internal mould, ×4.

Fig. 17. Dokimocephalid gen. et sp. indet., UT 89508, from 'bottom fauna', cranidium, internal mould, ×4.

All specimens from 'top fauna' (see text-fig. 1) unless otherwise stated.




JAGO, *Denagnostus*, *Pseudagnostus*, *Aphelaspis* spines. This ridge indicates that pygidium is slightly zonate; it appears to reflect outline of cephalic border and probably represents position of anterior margin of cephalon during enrolment. Narrow, shallow shoulder furrows; narrow, elevated, convex shoulders. Neither facets nor fulcra seen. Articulating device nowhere completely preserved; articulating furrow of moderate depth and width, with shallow articulating recess.

At anterior, axis width *c.* 0·45 that of pygidium. Anterior pair of axial segments outlined by narrow, shallow axial furrows. Both segments short (sag.); more posterior of pair slightly narrower (tr.) than other. Very faint traces of transverse axial furrow between anterior segments and between second segment and posteroaxis. Low, elongated node at centre of second segment.

Long posterior axial lobe only very faintly outlined, slightly expanded, and just reaches posterior border furrow. Small terminal node at posterior of posterior lobe. Some suggestion of internotular axis, but preservation not good enough to be certain. Pleural areas smooth.

### Agnostoid, gen. et sp. indet.

Plate 25, fig. 4

*Material.* Several cephala (including UT 89438b).

*Description.* Cephalon slightly longer than wide. Gently convex anterior border; wide shallow border furrow. Lateral borders not visible. Acrolobe appears unconstricted; smooth genae. Posteriorly directed spines arise from posterolateral corners; spine length cannot be determined but spines at least of moderate length. Deep, wide preglabellar median furrow flares forwards. Parallel sided glabella length *c.* 0·7 that of cephalon. Deep, wide axial furrows. Broadly rounded glabellar front. Straight, shallow transverse glabellar furrow very shallow at centre. Anteroglabella length about one-third that of glabella. No distinct glabellar node, although this may be function of preservation. Pair of faint lateral glabellar furrows placed well forwards on posteroglabella. Very broadly rounded glabellar rear; small, simple basal lobes connected by a wide connecting ring. Trace of cephalo-thoracic aperture visible.

*Discussion.* These cephala cannot be placed with certainty in any previously described genus or species and are hence left in open nomenclature.

### Order PTYCHOPARIIDA Swinnerton, 1915
### Superfamily PTYCHOPARIACEA Matthew, 1887
### Family PTEROCEPHALIIDAE Kobayashi, 1935
### Subfamily APHELASPIDINAE Palmer, 1960

*Discussion.* The classification of the Aphelaspidinae and related genera is difficult due to the considerable number of genera which show, or may be derived from, a basic aphelaspidine morphology. The concepts of *Aphelaspis* and the Aphelaspidinae were based originally largely on North American material by Palmer (1960, 1962, 1965) who described and figured numerous species.

The species of *Aphelaspis* accepted by Shergold (1982, p. 37) encompass considerable morphological variation. They include species such as *A. australis* Henderson, 1976, from Queensland, with a much shorter preglabellar field than the type species of *Aphelaspis*, *A. walcotti* Resser, 1938. *A. australis* shows similarities to some aphelaspidine-like trilobites from Siberia (see discussion on *A. cantori* sp. nov. below).

As noted by Shergold (1982), it is possible that quite a number of genera from the Siberian Platform were derived from a basic aphelaspidine morphology. These include *Apheloides* Ivshin, *Elegantaspis* Ivshin, *Kobayashella* Ivshin, *Nganasanella* Rosova, *Tamaranella* Rosova, *Kuraspis* Chernysheva, *Pedinocephalites* Rosova, *Maduiya* Rosova, *Amorphella* Rosova, *Ketyna* Rosova, *Kujandaspis* Ivshin, *Nyaya* Rosova, *Kaninia* Walcott and Resser, *Monosulcatina* Rosova, *Graciella* Rosova, and *Acrocephalaspina* Ergaliev. Various species of these genera were described and discussed by Ivshin (1962), Rosova (1963, 1964, 1968, 1977), and Appollonov and Chugaeva (1983). Comments on some of these genera are made below.

Ivshin (1962, p. 80) erected *Elegantaspis*, with type species *E. elegantula*, plus one other species, *E. beta*. An inspection of the features of these two species illustrated by Ivshin (1962, pl. 5) reveals no significant differences between them; hence, *E. beta* is a junior synonym of *E. elegantula*.

*Nganasella*, with type species *N. nganasanensis* Rosova, 1963 (p. 10, pl. 1, fig. 2), is a distinctive genus with a markedly tapering glabella, the length of which varies within the different species of the genus. I suggest that *N. interminata* Rosova, 1964, (p. 74, pl. 8, figs. 1–3, 5–11) be placed in synonymy with *N. tavgaensis*, since the specimens figured by Lazarenko and Nikiforov (1968, p. 13) appear to be conspecific.

*Tamaranella* is based on *T. bella* Rosova, 1963 (p. 10, pl. 1, fig. 5); the holotype and two other specimens were figured by Rosova (1964, pl. 18, figs. 12–15). I ascribe all these specimens to *Nganasella*; hence, *Tamaranella* is a junior synonym of *Nganasella*. Lazarenko and Nikiforov (1968) placed *Tamaranella* in *Apachia* Frederickson, but *Nganasella* is more appropriate. The species described by Lazarenko and Nikiforov (1968, p. 41, pl. 4, figs. 11–13) as *A. plana* should also be placed in *Nganasella*, as probably should *A. sima* Lazarenko and Nikiforov, 1968 (p. 42, pl. 7, figs. 18–26) but the poor preservation of the latter makes definite generic assignment difficult.

The type species of *Maduiya*, *M. maduensis* Rosova, 1963 (p. 11, pl. 1, fig. 11) is based on a single rather incomplete cranidium refigured by Rosova (1968, pl. 4, figs. 10–12). Rosova (1968) referred two other species to *Maduiya*, i.e. *M. sibirica* Rosova, 1963 and *M. composita* (Rosova, 1963); the latter's original assignment to *Idahoia*? was adhered to by Lazarenko and Nikiforov (1968). The holotype cranidium of *M. composita*, as illustrated by Rosova (1968, pl. 4, figs. 17–19), falls well within the range of morphologies illustrated by Rosova (1968, pl. 4, figs. 1–9) for *M. sibirica*; hence, *composita* should be regarded as a junior synonym of *sibirica*. Due to the incomplete nature of the holotype cranidium of the type species, *M. maduensis*, it is not clear whether *sibirica* and *maduensis* should be placed in the same genus. It is possible that the concept of *Maduiya* should be restricted to *M. maduensis* and that *sibirica* belongs in *Idahoia* or a related genus.

The genera *Amorphella* Rosova, 1963, with type species *A. modesta* Rosova, 1963 (p. 14, pl. 2, figs. 1 and 2), *Ketyna*, with type species *K. ketiensis* Rosova, 1963 (p. 16, pl. 2, fig. 7), and *Acrocephalaspina* Ergaliev, 1980, with type species *A. insueta* Ergaliev, 1980 (p. 130, pl. 14, figs. 13–15) appear to be closely related in that they all have a glabella which tapers slightly forwards, a bluntly rounded glabellar front, well-developed palpebral lobes, well-developed axial and border furrows, and a median swelling in the preglabellar field. It is arguable that *Acrocephalaspina* should be placed in synonymy with *Amorphella*, although the well-developed eye ridges and distinctly shorter glabella in the species of *Acrocephalaspina* illustrated by Ergaliev (1980, pl. 14) suggest that, for the time being at least, it may be better to keep the genera separate. The figures of *A. insueta*, *A. insueta spinosa*, *A. magna*, and *A. longa* illustrated by Ergaliev (1980) show no significant differences and I regard them all as *A. insueta*.

*Ketyna* Rosova, 1963 is similar to both *Amorphella* and *Acrocephalaspina* but the cranidium of *Ketyna* has much smaller posterolateral limbs, as shown by *K. ketiensis* (type species) and *K. glabra* figured by Rosova (1968, figs. 40 and 41). It should be noted, however, that the various species of *Ketyna* illustrated by Apollonov and Chugaeva (1983) suggest that *Acrocephalaspina* could be accommodated in *Ketyna*.

The generic position of *Amorphella*? *magna*, as described by Rosova (1968, 1977), is not clear, but I suggest that not all the specimens figured by Rosova (1977, pl. 8, figs. 1–15) belong in one species. For example, the length of the palpebral lobes of one cranidium (Rosova 1977, pl. 8, fig. 11) is about half that of another (ibid., fig. 4).

The genus *Jingxiana* Chien, 1974, from China, was erected by Lu *et al.* (1974) with *J. beigongliensis* as type species. Three other species, *J. zhuangliensis* Chien, *J. tangcunensis* Chien, and *J. traversa* Chien were erected by Lu *et al.* (1974). There seems almost no difference between the specimens illustrated, and it is probable that *zhuangliensis*, *tangcunensis*, and *transversa* are junior synonyms of *beigongliensis*. This is partly confirmed by the specimens of *tangcunensis* shown by Qiu (1984, pl. 3, figs. 1–3) which are indistinguishable from the holotype of *beigongliensis* (Lu *et al.* 1974, pl. 4, fig. 13).

### Genus APHELASPIS Resser, 1935

*Type species. Aphelaspis walcotti* Resser, 1938, p. 59, pl. 13, fig. 14.

*Diagnosis.* See Palmer (1965, p. 58).

*Discussion.* Palmer (1960, 1962, 1965) discussed *Aphelaspis* in some detail. The species he included show considerable variation in length of glabella, length of preglabellar field, and width of cranidial border. Australian species are *A. australis* Henderson, 1976 (p. 342, pl. 49, figs. 5–7), ?*A.* sp. aff. *A. australis* of Jell *in* Powell *et al.* (1982, p. 142, fig. 10, 7–8), and *A.* sp. undet. of Shergold (1982, p. 37, pl. 17, figs. 5 and 6). As noted by Shergold (1982, p. 37), ?*A.* sp. B of Öpik (1963, p. 76) may not belong in *Aphelaspis*. The poor preservation of ?*A.* sp. B makes a generic assignment inappropriate.

The new species of *Aphelaspis* described below, *A. cantori*, is similar to both *A. australis* and ?*A.* sp. aff. *A. australis* in that it has a short preglabellar field, deeply impressed axial furrows, and long palpebral lobes. As noted by Jell *in* Powell *et al.* (1982, p. 142), the exclusion of *australis* (and hence *cantori*) from *Aphelaspis* can be argued by virtue of the short preglabellar field, well-impressed axial furrows, and relatively long palpebral lobes. Although such species might form the basis of a new genus, there are already numerous genera with a basic aphelaspinid morphology (as noted above in the discussion of the subfamily) and I prefer to follow Jell and Henderson and assign *cantori*, along with *australis*, to *Aphelaspis*.

Both *A. cantori* and *A. australis* are similar to the single cranidium described by Ivshin (1962, p. 111, pl. 7, fig. 11) as *Kobayashella problematica* gen. et sp. nov., which probably belongs in *Aphelaspis*. If so, then *Kobayashella* is a junior synonym of *Aphelaspis*, but with only the one figured partial cranidium available it is not possible to make a meaningful comparison between *A. cantori*, *A. australis*, and *K. problematica*, particularly as Ivshin's (1962, p. 112, fig. 29) figure of *problematica* shows a much larger preglabellar field than is suggested by his pl. 7, fig. 11.

*A*? *kazachstanica* Lisogor, 1977 (p. 217, pl. 30, figs. 4 and 5) from Kazakhstan may also be close to *A. cantori*, although the glabella of *cantori* is longer. The pygidium assigned to *kazachstanica* is clearly different to that of *cantori*, but until more and better material of *kazachstanica* is figured a detailed assessment of the species cannot be made.

### *Aphelaspis cantori* sp. nov.

Plate 25, figs. 6–16

*Diagnosis.* Cranidium markedly wider than long. Glabella tapers gently forwards. Very gently impressed 1p furrows; other lateral glabellar furrows almost effaced. Deep axial furrows; fossulae present. Very short preglabellar field. Wide deep border furrow; wide anterior border. Prominent, long, centroanteriorly placed palpebral lobes separated from fixigenae by well-developed palpebral furrows. Thorax of thirteen segments. Small, transversely elliptical pygidium with axial length about three-quarters that of pygidium. Pygidium has narrow, shallow border furrow and very narrow border.

*Holotype.* Cranidium, UT 88521 (Pl. 25, fig. 6).

*Material.* Two specimens in which at least part of the cephalon, thorax, and pygidium are present (UT 88538); several isolated librigenae (UT 88520a); two cranidia with a few attached thoracic segments (UT 88532); two cranidia with attached librigenae; ten individual cranidia (including UT 88393a, 88521, 88522, 89406, 89424); and one specimen with a pygidium and twelve thoracic segments (UT 88393). Preservation varies from poor to reasonable.

*Description.* Surface ornament lacking on all specimens. Cranidium markedly wider than long. Length of gently convex glabella (including occipital ring) *c.* 0·7–0·75 that of cranidium; between the palpebral lobes glabellar width 0·4–0·5 that of cranidium. Glabella margins almost parallel up to 1p furrows, from where glabella tapers gently to almost straight glabella anterior. Axial and preglabellar furrows deeply impressed; distinct fossulae present. Very short, gently convex preglabellar field; wide, deeply impressed anterior border furrow about same width as gently convex border. Moderately impressed occipital furrow shallowest at centre.

Low, centrally placed occipital node. Lateral glabellar furrows almost effaced. Pair of very shallow, posteriorly directed 1p furrows about one-third of way along glabella. Faint traces of 2p and 3p furrows on some specimens (Pl. 25, fig. 13). Wide palpebral furrows deepen at either end; long, well-developed, gently curved palpebral lobes opposite centroanterior part of glabella. Well-developed, slightly curved eye ridges. Preocular sections of facial suture diverge slightly up to border furrow from where they converge. Postocular sections of facial suture diverge markedly.

Preocular areas of fixigenae slope down markedly to border furrow. Palpebral and posterior areas of fixigenae gently convex; fixigenae slope gently to broad, moderately impressed, posterior border furrow which widens abaxially. (Apparent differences in shape of illustrated cranidia (cf. Pl. 25, figs. 11 and 7) caused by slight tectonic distortion of enclosing sediments.)

Moderately convex librigenae. Gently impressed, wide border furrow. Almost flat border extends into narrow genal spine which reaches fourth thoracic segment.

Thorax of thirteen segments, each about twelve times as wide as long. Width of axis about one-third that of each segment. Moderately impressed pleural furrows wide up to geniculation, from where they narrow and are curved gently to posterior. Rounded pleural extremities.

Small pygidium with transversely elliptical outline. Gently impressed axial furrows. Axis width about three-quarters that of pygidium. Axial details not preserved. Slightly elevated pair of pleural ribs near anterior margin of pygidium; remainder of pleural areas almost smooth. Narrow, shallow border furrow; very narrow border.

*Discussion.* When compared with previously described species of *Aphelaspis*, *A. cantori* is closest to *A. australis*. However, *australis* has a more rounded glabellar front, better developed lateral glabellar furrows, shallower axial furrows, and a narrower anterior cranidial border than *cantori*. The fact that *cantori* is closest to *australis* lends support to the suggestion of Jell *in* Powell *et al.* (1982) that some Australian aphelaspidines may belong to a lineage distinct from the *Aphelaspis* of North America.

Of the various North American species of *Aphelaspis*, *A. cantori* is closest to *A. brachyphasis* Palmer, 1962 (p. 33, pl. 4, figs. 1–19) by virtue of the latter's short preglabellar field. The posterior part of the thorax and the pygidium of *brachyphasis*, as illustrated by Palmer (1962, pl. 4, fig. 14), are very similar to those of *cantori*, as illustrated herein (Pl. 25, figs. 10, 14). The palpebral lobes of *brachyphasis* are shorter than those of *cantori*; the dorsal furrows of *brachyphasis* are shallower than those of *cantori*.

### Genus EUGONOCARE Whitehouse, 1939

*Type species. Eugonocare tessellatum* Whitehouse, 1939, p. 226, pl. 23, figs. 15, 17 (*non* figs. 16, 18); pl. 25, fig. 7*b* (*fide* Henderson 1976).

### *Eugonocare* sp.

Plate 26, fig. 12

*Material.* One internal mould of a partial cranidium (UT 88361).

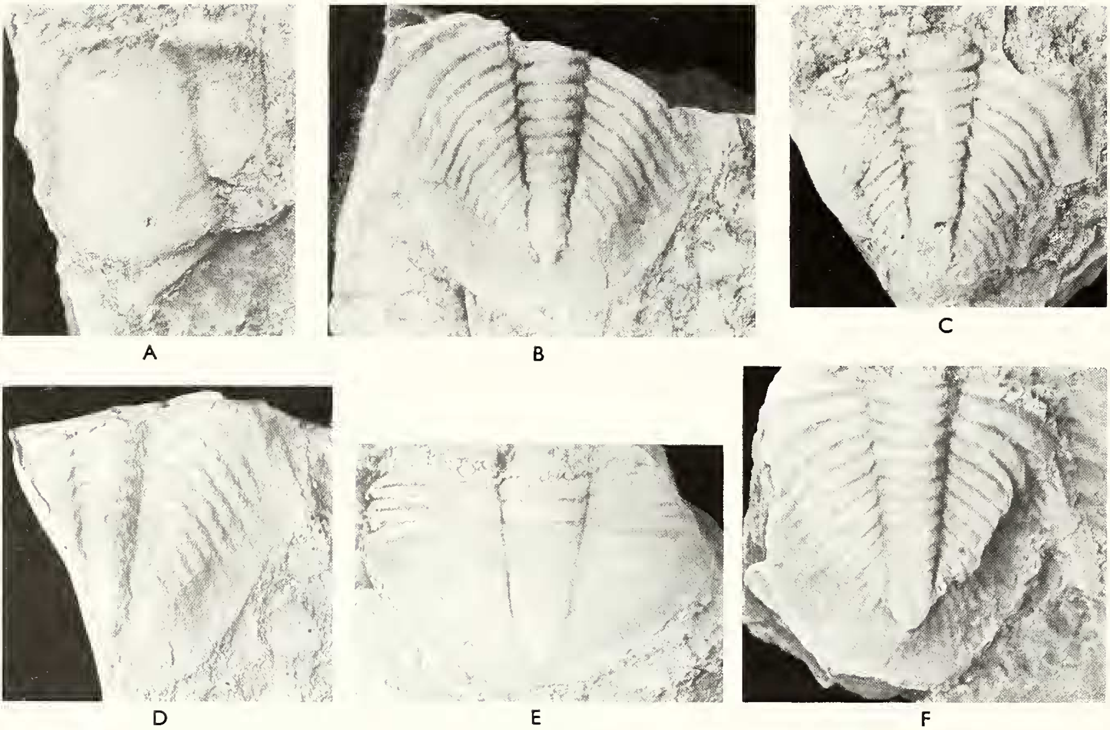
*Discussion.* As noted by Henderson (1976) and Shergold (1982) the cranidia of the various species of *Eugonocare* are essentially indistinguishable. Hence, as no pygidium is available this specimen is simply referred to *Eugonocare* sp.

### Superfamily DIKELOCEPHALACEA Miller, 1889
### Family DOKIMOCEPHALIDAE Kobayashi, 1935
### Dokimocephalid, gen. et sp. indet.

Plate 25, fig. 17

*Material.* The external and internal (UT 89508) moulds of a partial cranidium.

*Discussion.* This cranidium is placed in the Dokimocephalidae because of the combination of palpebral lobes placed close to the glabella, a short preglabellar field, and the bifurcating nature of the 1p glabellar furrows. In addition, the posterior branch of the 1p furrow has a sigmoidal shape, in common with many members of the Dokimocephalidae.




TEXT-FIG. 3. A–D, F, Leiostegiacean gen. et sp. indet. A, UT 88490, partial cranidium showing base of occipital spine, internal mould, ×3. B, UT 88490, pygidium, internal mould, ×2. C, UT 88482, pygidium, internal mould, ×2. D, UT 88411, pygidium, external mould, ×2. F, UT 88503, pygidium, internal mould, ×2. E, *Pseudoyuepingia vanensis* sp. nov., UT 89415, from 'middle fauna', pygidium and two thoracic segments, internal mould, ×2. All specimens except E from 'top fauna' (see text-fig. 1).

Superfamily LEIOSTEGIACEA Bradley, 1925
Leiostegiacean, gen. et sp. indet.

Text-fig. 3A–D, F

*Material.* One partial cranidium (UT 88490) and ten partial pygidia (including UT 88411, 88482, 88490, 88503).

*Description.* Gently convex cranidium with almost effaced glabella which extends to almost straight anterior border. Axial and preglabellar furrows shallow. Well-developed occipital furrow; base of large occipital spine. Eye ridges not showing; smooth fixigenae. Moderately deep border furrow; narrow border. Large, moderately convex pygidium, probably slightly wider than long. Axis has length *c.* 0·8 that of pygidium; it is outlined by moderately deep axial furrows which shallow posteriorly. Axis comprises fourteen or fifteen axial rings plus terminus; tapers evenly to posterior, apart from slight constriction near twelfth axial ring. Pleural areas strongly convex in adaxial areas but abaxially they slope markedly down to pygidial margin. Pleural areas comprise thirteen progressively smaller ribs separated by well-defined furrows. Ribs and furrows best defined in adaxial part of pleural areas, but can be traced clearly across flatter outer part of pleural areas almost to pygidial margin. Terrace lines on wide doublure seen where outer part of pleural areas not fully preserved (text-fig. 3B). Anterior rib much larger than other ribs and, in contrast to other ribs, widens abaxially and extends into broad, posteriorly directed macropleural spine of unknown length. Anterior pleural furrow considerably wider than other furrows; extends abaxially into small flat area near anterolateral corner of pygidium. Between spines, posterior margin evenly curved, except behind axis where it is deflected to anterior and also elevated slightly.

*Discussion.* The cranidium and the pygidia described above are included with some hesitation in one species. They occur within a distinctive, slightly micaceous coarse siltstone to fine sandstone, with the cranidium described above being the only one which is big enough to be matched with the quite large pygidia. The shape of the cranidium suggests affiliation with the Leiostegiidae; it is similar to the cranidium described by Lu and Qian (1983) as *Chuangia* (*Leptochuangia*) *benxiensis*. However, the pygidia described above have more pleural ribs than previously described species of the Leiostegiidae and appear to be more closely related to the Kaolishaniidae than the Leiostegiidae. Since the Leiostegiidae and Kaolishaniidae belong to the Leiostegiacea, the specimens are left in open nomenclature within that superfamily.

Superfamily CERATOPYGACEA Linnarsson, 1869
Family CERATOPYGIDAE Linnarsson, 1869
Subfamily PROCERATOPYGINAE Wallerius, 1895
Genus PROCERATOPYGE Wallerius, 1895

*Synonymy.* See Palmer (1968, p. 53), to which should be added *Proceratopyge* (Henderson 1976, p. 332; Shergold *et al.* 1976, p. 281; Lisigor 1977, p. 254; Yin and Lee 1978, p. 547; Yang 1978, p. 65; Shergold 1982, p. 49; Rushton 1983, p. 131), *Lopnorites* (Yang 1978, p. 67), and *Proceratopyge* (*Sinoproceratopyge*) (Lu and Lin 1980, p. 128).

*Type species. Proceratopyge conifrons* Wallerius, 1895, p. 57, pl. 1, fig. 6.

*Discussion.* Palmer (1968), Henderson (1976), and Shergold (1982) discussed *Proceratopyge* and its possible subgeneric groupings. However, at present there is no general agreement on the validity or otherwise of subgeneric divisions. Shergold *et al.* (1976) and Shergold (1982) followed Öpik (1963) in recognizing at least two subgenera, i.e. *Proceratopyge* (*Proceratopyge*) with five or less pygidial axial annulations, and *P.* (*Lopnorites*) with more than six such annulations. Henderson (1976, p. 333) regarded such subdivisions as valueless, while Yang (1978, p. 67) maintained that *Lopnorites* should retain full generic status. Lu and Lin (1980, p. 129) not only recognized *P.* (*Proceratopyge*) and *P.* (*Lopnorites*) but also erected a third subgenus *P.* (*Sinoproceratopyge*), with *P. kiangshanensis* Lu as type species. However, none of the six species placed in *Sinoproceratopyge* by Lu and Lin is particularly well known and certainly do not justify the erection of a new subgenus. I follow Rushton (1983) in regarding it as a synonym of *Proceratopyge*. Two species placed by Lu and Lin (1980, p. 129) with *Sinoproceratopyge*, i.e. *P. latilimbatus* (recte *latimbata*) Zhou (see Zhou *et al.* 1977, p. 232, pl. 70, figs. 11–13) and *P. latirhachis* Zhou (ibid., figs. 14–16) appear from their figured material to be synonyms.

Henderson (1976, p. 333) noted that *Kogenium* Kobayashi is of uncertain status, and that it should probably be regarded as a synonym of *Proceratopyge*, a move followed by Rushton (1983) and supported herein. Although Henderson (1976) suggested that useful subgeneric groupings are not yet apparent, I believe that it is possible to split the species described under *Proceratopyge* and *Lopnorites* into at least two broad groupings based on cranidial characters. The first group comprises species which have small palpebral lobes placed well forwards, large posterolateral limbs, and preocular sections of the facial suture which diverge only slightly; species include *P. conifrons* Wallerius, 1895, *P. magnicauda* Westergård, 1948, *P. similis* Westergård, 1947, *P. nathorsti* Westergård, 1947, *P.* aff. *nathorsti* of Rushton (1983), *P. rectispinata* (Troedsson, 1937), *P.* cf. *rectispinata* of Rushton (1983), *P. fragilis* (Troedsson, 1937), *P. cylindrica* Chien, 1961, and *P. taojiangensis* Zhou, 1977. The type species of *Proceratopyge* and *Lopnorites*, respectively *conifrons* and *rectispinata*, are included in this group, thus supporting Henderson's view that *Lopnorites* is a valueless taxon.

The second and much larger grouping comprises species possessing a palpebral lobe with a semicircular outline which is generally placed centrally or centroposteriorly in relation to the glabella. This group generally has strap-like posterolateral limbs and preocular sections of the facial suture which diverge considerably; species include *P. tullbergi* Westergård, 1922, *P. lata* Whitehouse, 1939, *P. nectans* Whitehouse, 1939, *P. gracilis* Lermotova, 1940, *P. liaotungensis* Kobayashi and

Ichikawa, 1955, *P.* cf. *P. liaotungensis* of Shergold and Cooper (1985), *P. asiatica* Ivshin, 1956, *P. chuhsiensis* Lu, 1956*a*, *P.* cf. *P. chuhsiensis* of Palmer (1968); *P. tenuita* Lazarenko, 1966, *P. capitosa* Lazarenko, 1966, *P. fenghwangensis* Hsiang, 1963, specimens figured as *P. conifrons* by Jegorova *et al.* (1963, pl. 10, figs. 11, 12), *P. constricta* Lu, 1964 (see Lu *et al.* 1965, pl. 115, fig. 1), *P. kiangshenensis* Lu, 1964 (ibid., fig. 3), *P. cryptica* Henderson, 1976, *P. orthogonialis* (Yang, 1978), *P. latilimbata* Lee *in* Yin and Lee, 1978, *P.* cf. *lata* of Shergold *et al.* (1976), and *P.* sp. of Shergold (1982). The two species described below, *P. gordonensis* sp. nov. and *P.* sp., belong to this group. However, within the group there is considerable variation with respect to development of plectral lines, length of preglabellar field, and pygidial characteristics. This group presumably corresponds in part to a grouping noted by Shergold *et al.* (1976, p. 283) of species 'characterized by rather widely diverging facial sutures, well-developed plectral lines, long (exag.) palpebral lobes with strap-like posterolateral limbs, and a pauci-furrowed pygidium'.

Species which cannot be placed in either group include *P. truncata* Yang *in* Zhou *et al.*, 1977, *P. corrugis* Romanenko, 1977, *P. triangula* Ivshin, 1962, *P. longispina* Ivshin, 1962, *P. latilimbata* Lee *in* Yang, 1978, *P. capitosa* Lazarenko, 1966, *P. latilimbata* Zhou *in* Zhou *et al.*, 1977, *P. latirhachis* Zhou *in* Zhou *et al.*, 1977, and *P.? brevirhachis* Zhou *in* Zhou *et al.*, 1977. The species described by Troedsson (1937) as *Lopnorites grabaui* may not belong in *Proceratopyge*.

### *Proceratopyge gordonensis* sp. nov.

Plate 26, figs. 1–10; Plate 27, figs. 1–8

*Diagnosis.* Gently tapering glabella; short (sag.) concave preglabellar field; 1p lateral glabellar furrows represented by pair of elongated pits, 2p and 3p furrows almost effaced. Semicircular palpebral lobes placed close to glabella. Narrow strap-like posterolateral limbs. Librigenae with wide borders. Pygidial axis with six or seven axial rings plus terminus. Very wide pygidial border. Pygidial pleural areas with traces of three segments. Anterior segment extends into long straight rearwardly directed spines.

*Holotype.* UT 88350a (Pl. 26, fig. 1).

*Material.* One almost complete specimen (UT 88350a); several isolated incomplete cranidia (including UT 88447, 88521); one specimen with a complete thorax and attached pygidium, librigena, and hypostome (UT 88351); several specimens with a thorax or partial thorax with attached cranidium and/or pygidium (UT 88389b, 88486, 89405, 89412); and about twenty pygidia (including UT 88350b, 88353, 88449, 88501, 88522).

*Description.* Cephalon wider than long. Length of gently convex glabella (including occipital ring) *c.* 0·8 that about half of cranidium. Between palpebral lobes, glabella width that of cranidium. Glabella tapers gently forwards to broadly rounded anterior. Axial furrow moderately impressed. Very gently impressed preglabellar furrow. Short, concave preglabellar field. Very gently impressed occipital furrow. 1p furrows represented by pair of shallow pits just forward of posterior of palpebral lobes; 2p and 3p furrows faintly developed near

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EXPLANATION OF PLATE 26

Figs. 1–10. *Proceratopyge gordonensis* sp. nov. 1, UT 88350a, holotype, almost complete specimen, external mould (intermediate distortion), ×2. 2, UT 88389b, pygidium, most of thorax plus posterolateral limb of cranidium, external mould, ×2. 3, UT 88351, pygidium, most of thorax, librigena and hypostome (see Pl. 27, fig. 8), internal mould, ×1·5. 4, UT 88521, cranidium, external mould, ×3. 5, UT 88389a, internal mould of ventral side of librigena showing faint radiating caecal pattern, ×2. 6, UT 88392, librigena, external mould, ×2. 7, UT 88486, specimen with pygidium, thorax, and most of cranidium, ×2. 8, UT 88447, partial cranidium, external mould, ×2. 9, UT 88350b, pygidium, internal mould, L form, ×2. 10, UT 89412, from 'middle fauna', cranidium and anterior part of thorax, external mould, ×2.

Fig. 11. Cranidium gen. et sp. indet., UT 88487, internal mould, ×3.

Fig. 12. *Eugonocare* sp., UT 88361, from 'bottom fauna', cranidium, internal mould, ×3.

All specimens from 'top fauna' (see text-fig. 1) unless otherwise stated.


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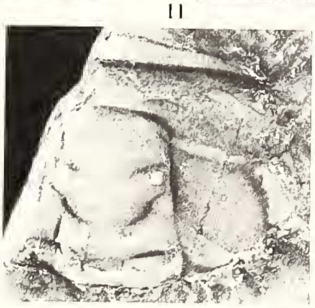
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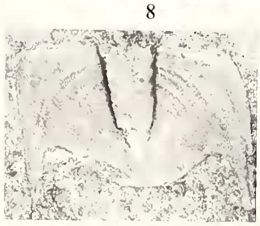
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JAGO, *Proceratopyge*, *Eugonocare*

anterior of palpebral lobes. Small, circular, centroposteriorly placed glabellar node. Shallow border furrow merges into narrow, very gently convex border. Semicircular, centrally placed, narrow, very slightly elevated palpebral lobes close to glabella; very shallow palpebral furrow. Small palpebral and anterior areas of fixigenae very narrow with moderately impressed posterior border furrow. Preocular sections of facial suture diverge up to border furrow from where they converge; postocular sections of facial suture diverge very markedly.

Gently convex librigena with faint caecal pattern radiating away from eye socle. Gently impressed border furrow; wide, almost flat border with faint terrace lines extends into narrow genal spine which also exhibits terrace lines.

Hypostome with convex median body and well developed elongated maculae.

Thorax of nine segments; moderately impressed axial furrows. Axial width *c.* 0·25 that of segment. Each segment about thirteen times as wide as long. Abaxial part of segments extend into spines which are directed strongly to the posterior. Wide pleural furrows narrow at geniculation and extend well along spine.

Large pygidium, length just under 0·3 that of entire carapace. Pygidium almost twice as wide as long (excluding axial half-ring). Convex axis outlined by moderately impressed axial furrows which shallow posteriorly. Axis comprises six or seven axial rings plus terminus. Axis tapers evenly with a slight constriction at third axial ring. Axial posterior bluntly rounded. Axis extends just on to border with narrow low ridge extending to posterior of axis. Very wide flat border; very wide doublure with terrace lines. At posterior, border has length (sag.) 0·25–0·3 that of pygidium. Three pairs of pleural furrows and three pairs of interpleural furrows present, best seen on smaller pygidia (Pl. 27, fig. 5; Pl. 26, fig. 7); become more effaced in larger pygidia (Pl. 26, fig. 1). The first pleural segment extends into a pair of long, broad, straight spines bearing terrace lines; spine length *c.* 1·3 that of pygidium. Posterior margin of pygidium broadly and evenly rounded.

*Discussion.* See discussion of *P.* sp. below.

### *Proceratopyge* sp.

Plate 27, figs. 9–11

*Material.* Three specimens with most of the cranidium, thorax, and pygidium present (UT 88407, 89421, 89448). Two of these possess at least part of a librigena. A fourth specimen comprises the pygidium and part of eight thoracic segments.

*Description.* Cephalon wider than long. Gently convex glabella tapers slightly forwards to broadly rounded anterior. Axial furrow moderately impressed; very gently impressed preglabellar furrow. Short, concave preglabellar field. Very gently impressed occipital furrow shallows abaxially. Lateral glabellar furrows almost entirely effaced. Very small posteriorly placed node. Details of anterior border area nowhere well preserved. Semicircular, centrally placed, narrow palpebral lobes close to glabella; palpebral furrows so shallow that it is difficult to distinguish palpebral lobes from flat, small palpebral areas of fixigenae. Narrow posterior areas of fixigenae with shallow border furrow. Preocular sections of facial suture diverge slightly; postocular sections of facial suture diverge markedly.

Gently convex librigenae; gently impressed border furrow merges with almost flat border. Terrace lines on both furrow and border. Border extends into gently curved spine which bears terrace lines and extends to level of sixth thoracic segment.

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EXPLANATION OF PLATE 27

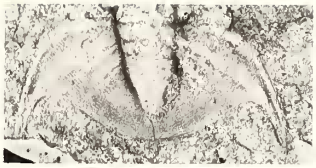
Figs. 1–8. *Proceratopyge gordonensis* sp. nov. 1, UT 89405, from 'middle fauna', pygidium and four thoracic segments, internal mould, ×2. 2, UT 88501, pygidium with widely divergent spines, external mould, W form, ×2. 3, UT 88350b, pygidium, internal mould, W form, ×2. 4, UT 88353, pygidium, external mould, L form, ×2. 5, UT 88449, pygidium, external mould, L form, ×3. 6, UT 88522, pygidium, internal mould, L form, ×5. 7, UT 88385, hypostome, external mould, ×5. 8, UT 88507, hypostome, internal mould (counterpart of UT 88351; see Pl. 26, fig. 3), ×5.

Figs. 9–11. *Proceratopyge* sp. 9, UT 89448, from 'middle-fauna', pygidium and posterior part of thorax, external mould, ×2. 10, UT 89421, from 'middle fauna', almost complete specimen, external mould, ×2. 11, UT 88407, specimen with most of cephalon, partial thorax, and partial pygidium, external mould, ×2.

Figs. 12–14. *Pseudoyuepingia vanensis* sp. nov., from 'middle fauna', 12, UT 89414, pygidium, internal mould, ×2. 13, UT 89433, pygidium, internal mould, ×3. 14, UT 89415, holotype, internal mould, ×2.

All specimens from 'top fauna' (see text-fig. 1) unless otherwise stated.

1



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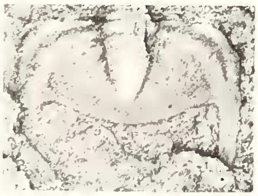
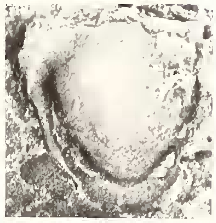


6



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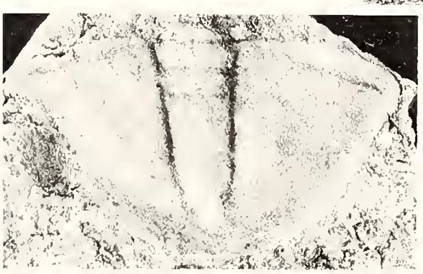
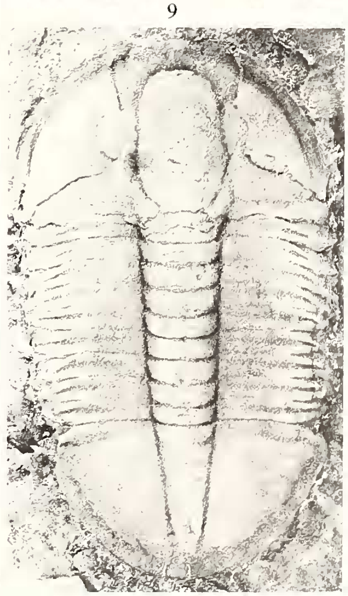


12

13



14

JAGO, *Proceratopyge*, *Pseudoyuepingia*

Impression of hypostome crushed under glabella seen in Pl. 27, figs. 10 and 11, but no separate hypostome available for description.

Thorax of nine segments; moderately impressed axial furrows. Each segment about thirteen times as wide as long. Abaxial parts of segments appear to extend into spines, but details not clear. Pleural furrows moderately to gently impressed.

Pygidium length *c.* 0·2–0·25 that of entire specimen. Pygidium about twice as wide as long (excluding axial half-ring). Axial furrows moderately impressed. Axis comprises five axial rings, plus terminus; length 0·75–0·80 that of pygidium (excluding axial half-ring). Moderately shallow border furrow, with terrace lines and gently convex border. Two pairs of pleural furrows and two pairs of interpleural furrows clearly visible.

Pair of gently curved, long, thin spines emerge from near posterior of anterior pleural segment and extend past posterior of pygidium. Spines deflected outwards at point where they leave pygidial margin; at their anterior they diverge slightly before becoming slightly convergent to posterior. Only two specimens show posterior pygidial margin; that in Pl. 27, fig. 9 is more sharply rounded than Pl. 27, fig. 10.

*Discussion.* As discussed below, the specimens described can be differentiated from previously described species of *Proceratopyge*, but their preservation is such that the erection of a new species is not warranted. *Proceratopyge* sp. is quite close to *P. gordonensis* sp. nov. The lateral glabellar and palpebral furrows of *P.* sp. are more effaced than those of *gordonensis*, and the cephalic border of *gordonensis* is wider than that of *P.* sp. The two differ more clearly in pygidial characteristics: the axis of *gordonensis* has six or seven axial rings, plus a terminus, while that of *P.* sp. has only five, plus a terminus. The pleural details are clearer in *gordonensis*; the pygidial spines of *gordonensis* are straight and broad, while those of *P.* sp. are thinner and curved. Both *P. gordonensis* and *P.* sp. belong in the second species group noted in the generic discussion, hence the latter will be compared only with species in this grouping.

Compared with previously described Australian species of *Proceratopyge*, *P. gordonensis* differs from *P. nectans*, *P. cryptica*, and *P. lata* in not having a distinct plectrum, although this is a rather variable feature (e.g. cf. cranidia of *P. lata* figured by Henderson 1976, figs. 5 and 8). The preglabellar details of *P.* sp. are too poorly preserved to allow comparison of the plectral details. The glabella of *gordonensis* is larger than that of *nectans* and *cryptica*, and longer than those in many specimens of *P. lata* illustrated by Henderson (1976, pl. 48) and Shergold (1982, pl. 16). However, the cranidia of *P. lata* illustrated by Henderson (1976, pl. 48, figs. 4, 10) and Shergold (1982, pl. 16, figs. 1 and 2) have a glabella of similar length to that of *gordonensis*. The pygidial spines of *P. lata* are much finer than those of *P. gordonensis*. The extremities of the palpebral lobes of both *P. gordonensis* and *P.* sp. are closer to the glabella than in *lata*, *cryptica*, *nectans*, or *P.* sp. of Shergold (1982). The preglabellar field of *P.* cf. *chuhsiensis* Lu of Öpik (1963) is longer than that of either Tasmanian species. The glabella of *P.* cf. *lata* Whitehouse illustrated by Shergold *et al.* (1976, pl. 40, fig. 1) from northern Victoria Land, Antarctica, is shorter than that of either *gordonensis* or *P.* sp.; it is less effaced than that of *P.* sp.

The glabella of the Swedish *P. tullbergi* is shorter than that of either Tasmanian species. Of the various Chinese species of *Proceratopyge*, *P. fenghwangensis* Hsiang is probably closest to *gordonensis* and *P.* sp. in cranidial characters. It differs, however, in having a distinct plectrum; the preglabellar fields of both *gordonensis* and *P.* sp. are shorter than that of *fenghwangensis*; the base of the pygidial spines of *fenghwangensis* is bigger than those of *P.* sp., and the pygidial border of *fenghwangensis* is narrower than that of *gordonensis*.

### Genus PSEUDOYUEPINGIA Chien, 1961

*Synonymy. Pseudoyuepingia* Chien, 1961, p. 106, Lu *et al.* (1965, p. 506), Yin and Lee (1978, p. 534), Lu and Lin (1980, p. 127). *Iwayaspis* Kobayashi, 1962, p. 122, Palmer (1968, p. 53), *non* Lazarenko *in* Datsenko *et al.* (1968, p. 184).

*Type species. Pseudoyuepingia modesta* Chien, 1961, p. 106, pl. 5, figs. 5–7.

*Diagnosis.* Semicircular cranidium with long, very slightly tapered to parallel sided glabella which has bluntly rounded anterior. Poorly developed to effaced lateral glabellar furrows. Shallow occipital furrow. Short preglabellar field. Small, centro-anteriorly placed, semicircular palpebral lobes close to glabella. Preocular sections of facial suture slightly divergent; postocular sections of facial suture diverge markedly enclosing subtriangular posterior areas of fixigenae. Almost flat librigenae with long genal spines.

Thorax of eight or nine segments; spinose pleurae. Large semicircular pygidium with low axis of five or six axial rings plus terminus; axis extends to border. Pleural furrows in anterior part of pleural areas better defined than at posterior where shallow or effaced. Narrow, flat pygidial border.

*Discussion. Pseudoyuepingia* belongs in a group of trilobites which show characteristics of both the Asaphidae and Ceratopygidae. As noted by Shergold (1982, p. 52), this group includes *Yuepingia* Lu, 1956*b*, *Iwayaspis* Kobayashi, 1962, *Eoasaphus* Kobayashi, 1936, *Norinia* Troedsson, 1937, *Charchaqia* Troedsson, 1937, *Haniwoides* Kobayashi, 1935, and *Aplotaspis* Henderson, 1976. To this group should be added *Metayuepingia* Liu *in* Zhou *et al.*, 1977, *Cermatops* Shergold, 1980, and *Yuepingioides* Lu and Lin, 1984. Various authors have assigned the above genera to different subfamilies, both within the Asaphidae or Ceratopygidae. However, I prefer to leave them in a single group within the Ceratopygidae, as was done by Palmer (1968), Henderson (1976), and Shergold (1982).

I follow Lu and Lin (1980, p. 127) in placing *Iwayaspis* (type species *I. asaphoides* Kobayashi, 1962, p. 122, pl. 6, figs. 1–10; pl. 8, fig. 24) in synonymy with *Pseudoyuepingia*, although the latter's type species, *P. modesta*, is not particularly well preserved (see Chien 1961, pl. 5, figs. 5–7, and Lu *et al.* 1965, pl. 103, figs. 1–3 where the type material is refigured). My diagnosis of *Pseudoyuepingia* is based on *P. modesta*, *P. asaphoides*, *P. zhejiangensis* Lu and Lin, 1980, and *P. vanensis* sp. nov. described below.

*Pseudoyuepingia* is close to *Yuepingia* but, as noted by Palmer (1968, p. 56), the palpebral lobes of *Yuepingia* are placed further to the posterior than those of *Pseudoyuepingia* [= *Iwayaspis* in Palmer] and the shapes of the posterolateral limbs of the cranidia are different. It can be argued that such differences are of specific rather than generic importance, in which case *Pseudoyuepingia* becomes a junior synonym of *Yuepingia*. However, *Yuepingia* is neither particularly well known nor, with the exception of *Y. glabra* Palmer, 1968 (p. 56), particularly well illustrated, so I prefer to treat *Yuepingia* and *Pseudoyuepingia* as separate genera.

Lazarenko *in* Datsenko *et al.* (1968, pp. 184–185) described two new species of *Iwayaspis*, *I. caelata* and *I. curta*. Only two pygidia were figured for *I. curta*, so a detailed comparison with other taxa is not possible. *I. caelata* has a relatively short glabella, large preglabellar field, small circular palpebral lobes, and strap-like posterolateral areas of fixigenae; hence, it would appear to belong in *Yuepingia* rather than *Pseudoyuepingia*. *Metayuepingia* was erected by Liu *in* Zhou *et al.* (1977) with *M. angustilimbata* Liu *in* Zhou *et al.*, 1977 (p. 216, pl. 64, figs. 1–3) as type species. Two other species, *M. intermedia* and *M. latilimbata*, were erected by Liu *in* Zhou *et al.* (1977, pp. 216–217); *M. intermedia* appears to be a synonym of *M. angustilimbata* and it is possible that *M. latilimbata* is so too.

### *Pseudoyuepingia vanensis* sp. nov.

Plate 27, figs. 12–14; text-fig. 3E

*Diagnosis.* Semi-elliptical cephalon wider than long. Long glabella tapers slightly to broadly rounded glabellar anterior. Gently impressed axial and preglabellar furrows. Shallow occipital furrow. Short, almost flat preglabellar field; almost flat border. Lateral glabellar furrows effaced. Centro-anteriorly placed, semicircular, palpebral lobes close to glabella. Large triangular posterolateral areas of fixigenae. Preocular sections of facial suture diverge slightly up to border furrow, from where they converge markedly; sinuous postocular sections of facial suture diverge markedly. Gently convex, smooth, wide librigenae. Thorax of nine segments. Large semicircular pygidium with low axis comprising five or six axial rings plus terminus. Axial rings become poorly defined to posterior.

Poorly defined pleural furrows on anterior part of pleural areas; posterior part of pleural areas smooth. Narrow, flat pygidial border.

*Holotype*. UT 89415 (Pl. 27, fig. 14).

*Material*. One incomplete specimen (UT 89415), one incomplete cranidium, and five pygidia (including UT 89414, 89415, 89433).

*Description*. Cephalon has semicircular outline; wider than long. Length of gently convex glabella (including occipital ring) *c*. 0·8 that of cranidium. Between palpebral lobes, glabella has width about half that of cranidium. Glabella tapers very slightly forwards to broadly rounded anterior. Gently impressed axial and preglabellar furrows. Short, almost flat preglabellar field slopes slightly down to shallow border furrow. Narrow, slightly elevated border. Shallow occipital furrow. Lateral glabellar furrows effaced. Presence or absence of glabellar node not determined. Semicircular, centro-anteriorly placed, slightly elevated palpebral lobes close to glabella; very shallow palpebral furrow. Small, almost flat palpebral and anterior areas of fixigenae with shallow border furrow. Preocular sections of facial suture diverge slightly up to border furrow, from where they converge markedly; sinuous postocular sections of facial suture diverge markedly.

Gently convex, smooth, wide librigena with very shallow border furrow and narrow flat border. Presence or absence of genal spines not determined. Hypostome unknown.

Thorax of nine segments; moderately deep axial furrows. Axial width *c*. 0·25 that of segment. Shallow pleural furrows deepen and narrow abaxially. Pleurae appear to extend into short spines.

Large, gently convex, semicircular pygidium; length *c*. 0·3 that of entire carapace; wider than long. Low, gently convex axis; moderately deep axial furrows. Axis comprises five or six axial rings, plus terminus; only anterior three axial rings clearly distinguished. Axis has slight centro-posteriorly placed constriction. Up to three poorly defined pleural furrows distinguished in anterior part of pleural areas; posterior part of pleural areas smooth. Shallow border furrow; narrow flat border. Posterior margin evenly curved.

*Discussion*. *Pseudoyuepingia vanensis* differs from *P. modesta* and *P. asaphoides* in that it has a more effaced glabella, which is also narrower than those of *modesta*, *asaphoides*, and *P. zhejiangensis* Lu and Lin, 1980 (p. 127, pl. 2, figs. 8 and 9). The palpebral lobes of *vanensis* are smaller than those of other species of *Pseudoyuepingia*, and placed closer to the glabella than those of *modesta*. *P. zhejiangensis* has eight thoracic segments whereas both *P. vanensis* and *P. modesta* have nine. The pleural furrows of *vanensis* are shallow and become effaced towards the posterior, as do those of *modesta* and *zhejiangensis*; those of *asaphoides* are better developed.

### cranidium, gen. et sp. indet.

Plate 26, fig. 11

*Material*. Partial cranidium, UT 88481.

*Description*. This very poorly preserved specimen is figured for completeness.

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